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Abstract

PRESSURE VESSEL FOR THE FIRST CZECHOSLOVAK NUCLEAR POWER STATION

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One of the basic power reactor types tested within the framework of a wide research of different prototypes in USSR and people's democratic states is the pressure vessel reactor fuelled with pin type fuel elements of natural uranium, moderated with heavy water and cooled with gas.

The basic dimensions of the reactor pressure vessel resulted from the mentioned conception and from the fixed power rating of 150 MWe. In the prescribed minimal spacing of the fuel channels large vessel dimensions and wall thickness were reached which are difficult to manufacture to weld and check. That is why the design must solve the question of optimal dimensions and designs in most troublesome parts of the vessel as the cover, the flanged joint, the conical support and above all the inlet and outlet connecting branch for the cooling gas ducting. These problems were solved theoretically and experimentally on models by means of tensometry and photoelasticimetry. Various effects on the magnitude of stress concentration in places of weakness in the cylindrical pressure vessel due to connecting branches were studied: the magnitude and shape of the hole, the number of holes on the circumference, the reinforcement of the hole with connecting branch and the local transition modification of the branch into the pressure vessel wall.

In welded pressure vessels there is the danger of sudden brittle fractures.

For this reason the informative bending tests of large bodies with notches were carried out. The result shows the dependence of strength upon magnitude and notch effect. The analysis of deformation characteristics and specification of fast plastic and fast brittle fracture ideas are mentioned.

Furthermore a project was worked out for systematic testing of large bodies and specimens as thick as the real pressure vessel wall. Tests of these specimens are carried out on large load apparatus of 6000 t force. Results of some tests of large bodies completed to this time were studied as well as their value with respect to the character of boundary condition of the reactor vessel.

Critical analysis of the importance of tests on small specimens and results of tests according to transition temperature and crack arrest temperature was carried out.

The pressure vessel will be manufactured from low carbon, fine grain, manganese structural steel produced in non-aging quality in open-hearth furnaces and cast at atmospheric pressure into ingots weighing 43 t.

Both shaped forgings of semi-products with branches, and slabs from which plate semi-products are pressed are made from ingots by free forging under a 12 000 t press. From the semi-products segments are die pressed under a 12 000 t press, from which parts of the pressure vessel are welded by electroslag welding. The complete units from the finished parts, i.e. the cover and bulk of the pressure vessel, are made by circumferential electroslag welding, semi-automatic welding under protective atmosphere of CO_2 and manual welding. The pressure vessel is stress relieved in a single-purpose electrical resistance furnace.

Before welding it was necessary to carry out extensive experimental work to attest the weldability of steel, to develop suitable additional materials for all welding methods to master the technology of welding and preheating, to verify the magnitude of stress and strain, to find suitable post-welding heat treatment etc. These tests were carried out not on plates only, but on full scale parts as well.

The whole technological cycle of the pressure vessel manufacture from the production of steel till the testing of the welded and heat treated pressure vessel, includes a sequence of operations affecting the quality of the base material and of the welded joints. For this reason inter-operational take-over tests are inserted into various phases of manufacture which have the purpose to identify the defective piece in time.

To test the development manufacturing technology and to draw conclusions as to the safety of the pressure vessel, the manufacture of the shortened model of this vessel in scale 1:1 is now nearing the end. The model is without the plain cylindrical portion and the ring with branches for the cooling gas inlet. The model will be put to strength and functional tests.